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G1N NBLE N25E1

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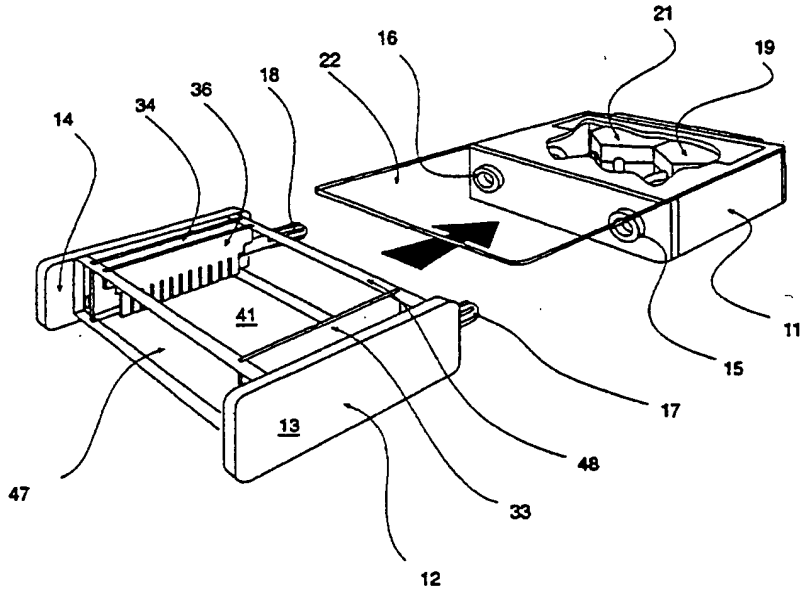
(54) Low voltage electrophoresis unit with separable battery pack

(57) A portable, self-contained, low voltage, electrophoresis unit employs a discrete separation chamber 41, with electrodes and gel casting plates 33, 34 and a battery pack 11, with push-fit complementary interfitting spaced electromechanical connectors 15, 16, 17, 18, to achieve an integrated coupled assembly which is readily dismantled, eg to allow a power supply change. The operating voltage is not more than 50 volts, and is preferably 18 volts supplied by two 9 volt batteries in series. A transparent lid 22 is attached to the battery pack and covers all of the assembly.

Fig 6



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig 1

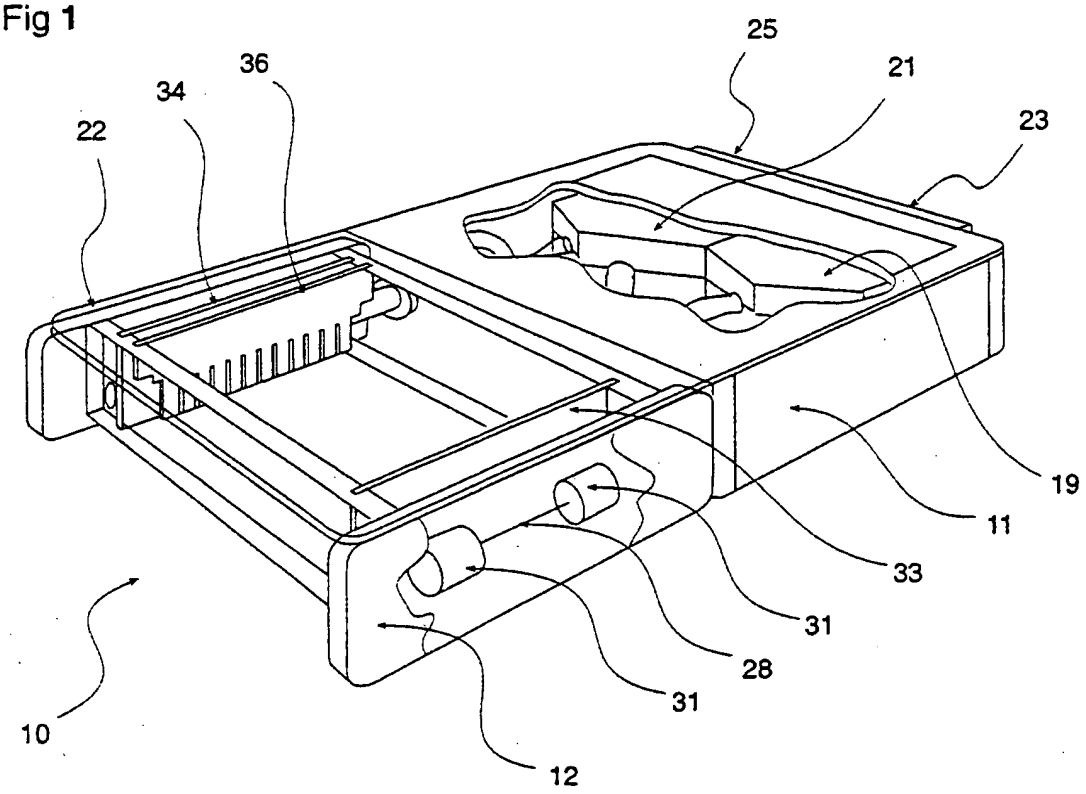
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Fig 2

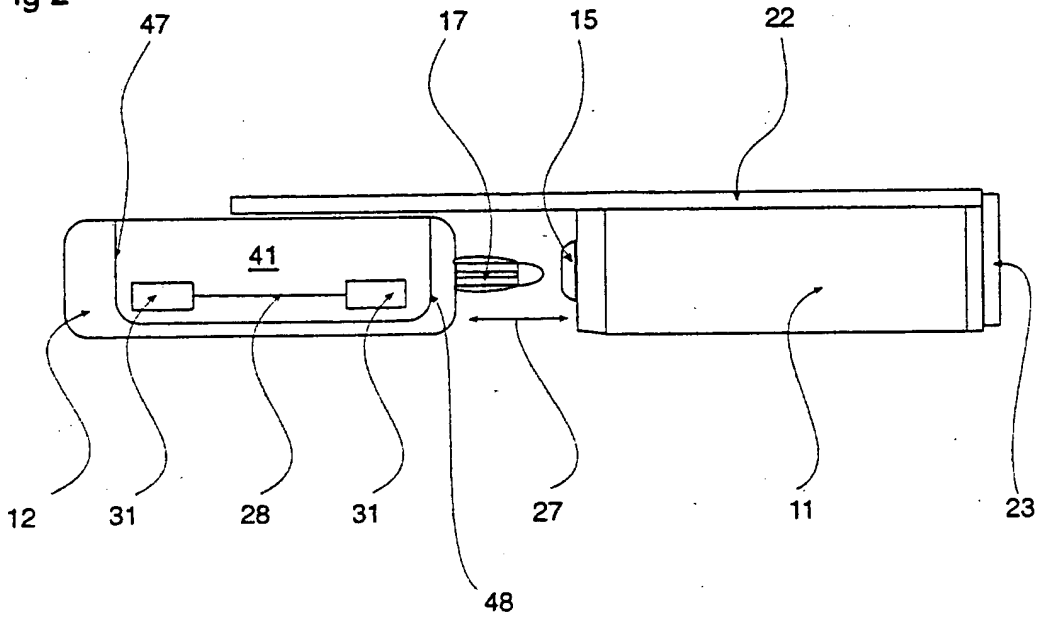
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Fig 3

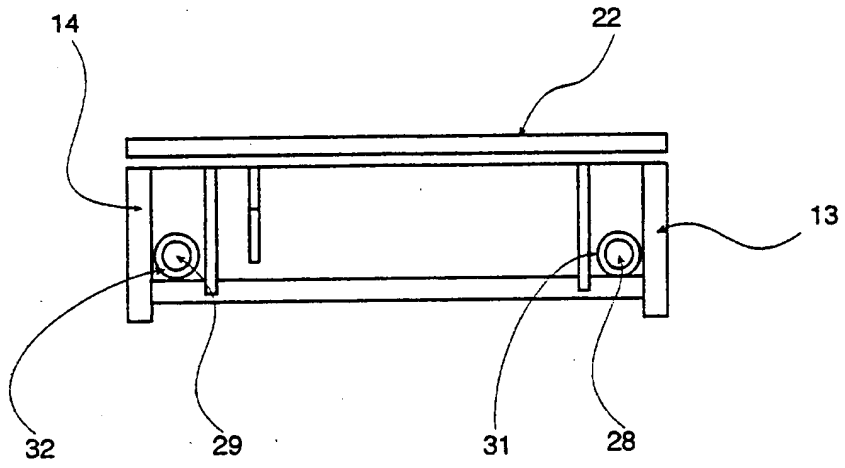

Fig 4

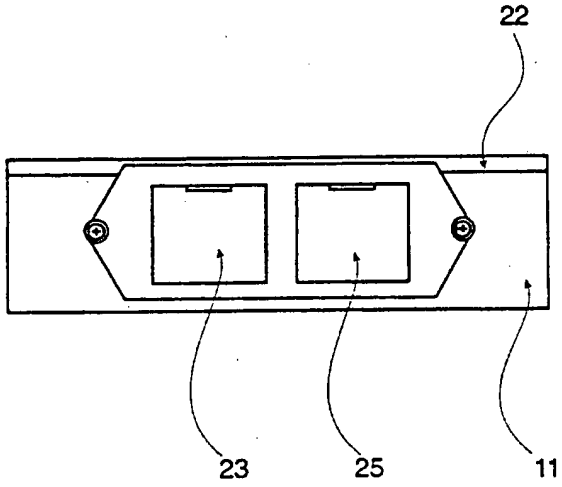

Fig 5a

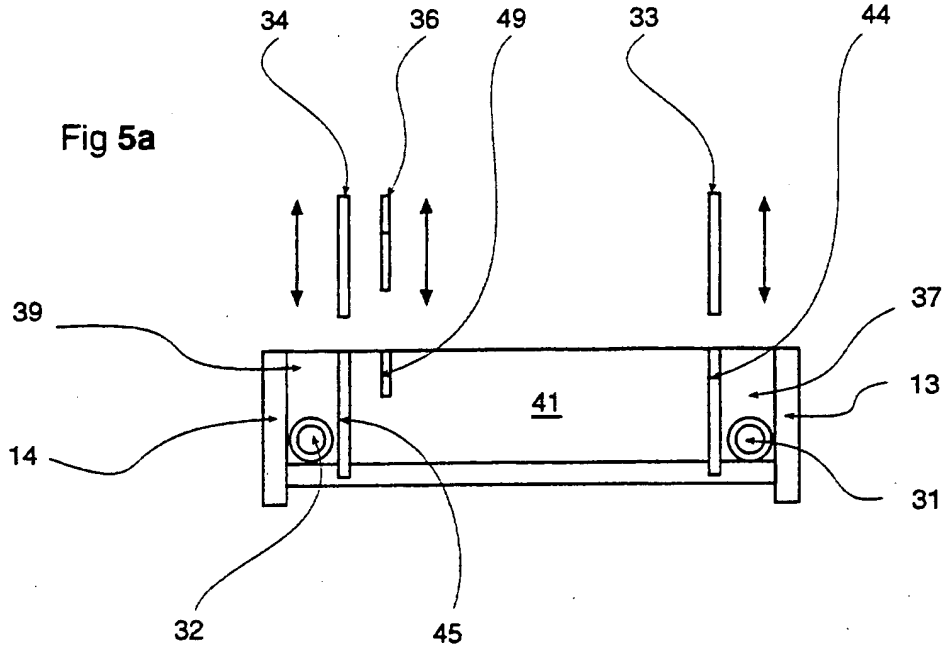
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Fig 5b

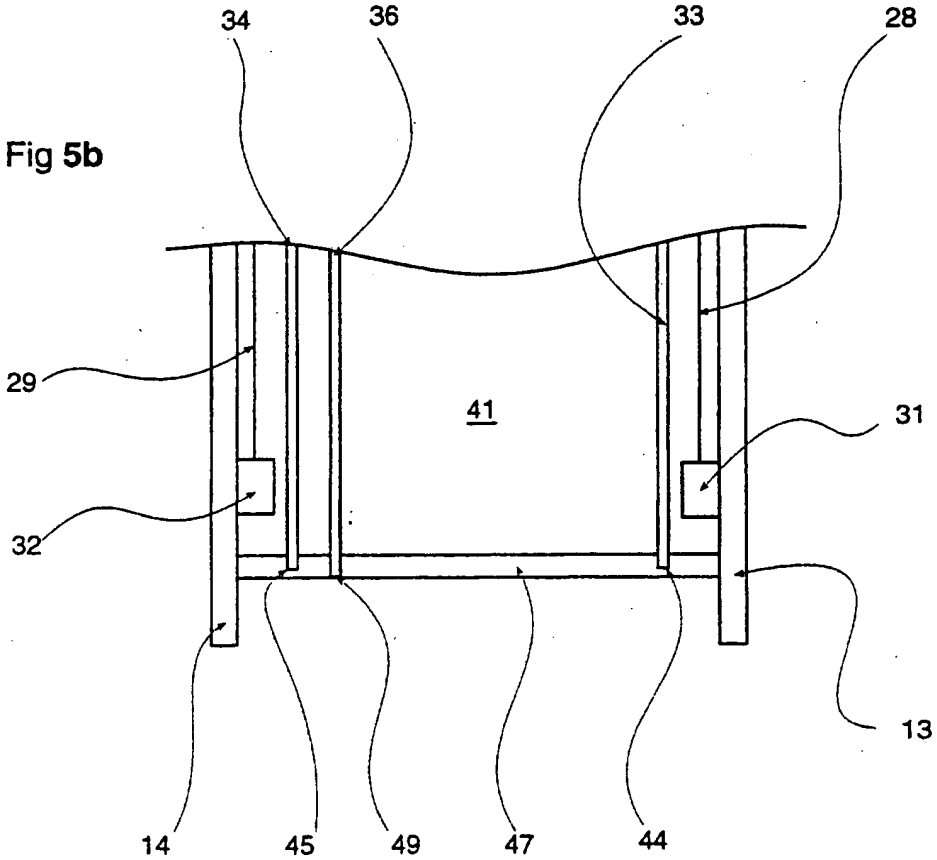
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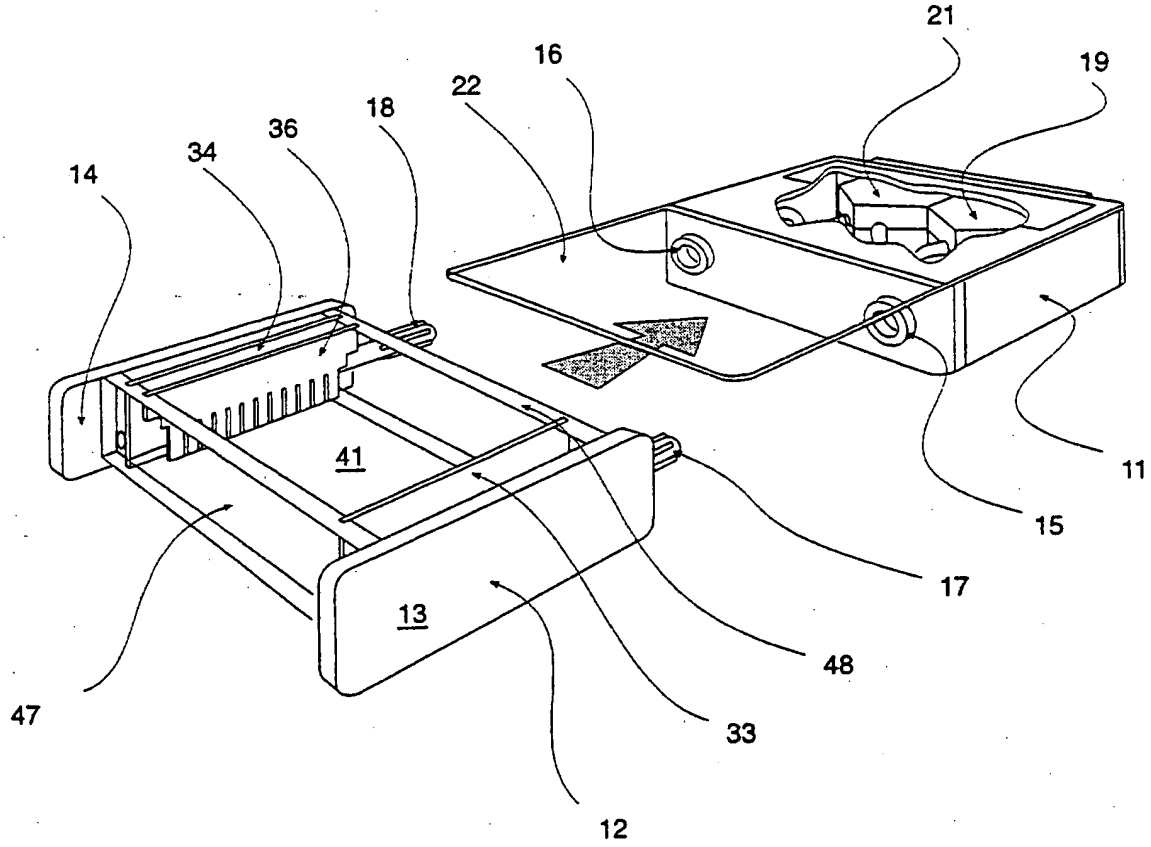
Fig **6**



Low Voltage Electrophoresis

This invention relates to laboratory and field measurement, analysis, appraisal or testing equipment and is particularly concerned with self-contained, electrically powered units for discrete samples.

A particular topic is electrophoresis, that is broadly the generation of a discernible characteristic behaviour or effect in a sample, under the application of an electrical field, typically generated by an applied differential voltage potential across spaced electrodes in the sample.

The effect may be realised or expressed in a physical separation or dis-solution of constituents from a mixed sample - typically in solution or gel form.

More specifically, electrophoresis is essentially the movement of charged molecules in an electric field generated between spaced electrodes of opposite polarity - so that each molecule moves towards an electrode of opposite electrical polarity.

In an aqueous solution the rate of migration of the molecules depends on molecular shape and electrical charge.

In practice, electrophoresis can be carried out in a gel, in order to separate molecules of different size, since in a gel, the migration rate of a molecule is also influenced by its size.

Such differential migration arises because the gel comprises a complex matrix or network of pores, through which the molecules must travel to reach an electrode. The smaller the molecule, the faster it can migrate through the gel.

Electrophoresis can therefore separate molecules according to size - and in a distinct pattern, with the smallest molecules furthest from the starting-point.

Generally, the separation of biological macromolecules can be achieved by various analytical techniques, such as centrifugation, chromatography and spectrometry.

Electrophoresis is a separation technique of particular simplicity, ease of performance and interpretation - and yet power.

Experimentally, electrophoresis is typically performed by running a sample through a chemical matrix, such as polyacrylamide or agarose, by use of an electric charge.

Electrophoretic motion can also be detected by a so-called 'moving boundary' method, in which a boundary is created between a particulate solution under examination and a pure solvent sample. Boundaries of various shapes and sizes reflect diversity of constituent and attendant electrophoretic mobility.

Molecules that differ by only the smallest modification or size can be separated by

electrophoresis, in quantities as low as a few attomoles (10 to the minus 21).

Thus electrophoresis is used in molecular biology for the separation of macromolecules such as nucleic acids, proteins and carbohydrates.

Macromolecules will either be inherently charged (as in the case of nucleic acids) or, by chemical modification, can have a positive or negative charge attached to them.

In practice, a sample containing the macromolecule is added to a well at the top of a chemical matrix sandwiched between glass plates.

A high voltage (typically of the order of some 100 volts) potential is applied across the matrix, causing the macromolecules to migrate into the matrix - at a rate that is dependant on their size and or charge.

The high voltage is applied for a fixed period of time (typically 2 or 3 hours) - over which molecules of different size and charge will have migrated at different rates.

The matrix is then removed from the glass plates and stained with a dye that will bind to the sample molecules, showing their positions relative to other molecules within the matrix.

Typically, the chemical matrix is either agarose or polyamide. Both of these molecules are in solution phase when heated above 60 degrees Centigrade and solidify by cross-linking when cooled in the form of a gel.

Such a gel is essentially a liquid solution held in the solid phase by the cross-linkage, acting as a 'web' through which molecules can migrate.

Electrophoresis finds diverse application from research into the mapping and sequencing of DNA, analysis of amino acid composition of peptides and proteins (where some 3000 different molecules may be separated on one gel) to diagnostic applications, such as the 'fingerprinting' of DNA fragments for forensic analysis, or the separation of blood proteins for identification and treatment of disease.

In genetic DNA characterization, a given piece of DNA, broken up by enzymes, produces a distinctive fragmentation - which can be separated, by electrophoresis, to produce a pattern for comparative testing with reference samples.

A common underlying electrophoretic principle can be applied to such diverse tests - in which a gel solution is poured between two glass plates, cooled until the gel has solidified, whereupon the sample is applied to the top of the gel and then an electric field or current applied across the gel.

This field carries the charged molecule(s) into the gel and allows their migration to a distance within the gel dependent on the size and charge of the sample and the gel matrix, applied voltage and time of running of the gel.

A typical electrophoresis unit, for testing and experiment, embodies a separation

chamber, spaced chamber electrodes connected to terminals for an external (and normally relatively high voltage - eg of some 100 volts) power supply, with additional gel casting plates and combs in the chamber, to help control the onset and pattern of the desired effect in the sample.

The separation unit may be orientated vertically or horizontally.

Provision may be made for temperature control, for example cooling, conveniently achieved with a water jacket, to contrive optimal running conditions.

The separation chamber walls may be translucent, allowing illumination to assist visualisation of the effect.

The reliance placed hitherto on relatively high voltage (some 100 volts) power supplies for generating the necessary electrical field within a test separation chamber to achieve the desired electrophoresis in the sample has not lent itself to field testing, outside laboratory facilities and conditions.

However, with the present invention it has been found possible to use relatively low voltages, whilst maintaining the electrophoretic effect.

It has also been found possible to use batteries to generate and sustain suitable low operating voltages.

This in turn has enabled the construction of electrophoresis units with an integral, self-contained, power supply.

According to one aspect of the invention a self-contained electrophoresis unit comprises a separation chamber, a power pack, complementary interfitting electrical support connectors mounted in the separation chamber and the power pack, to allow the separation chamber and power pack to mate together mechanically and electrically in an integrated unit.

The separation chamber and power pack are otherwise individually self-contained and, as such, can readily be separated - allowing the connection of freshly (re-)charged power supplies.

In a particular construction, intended for horizontal orientation, a separation chamber in the form of a shallow tray is mounted from a pair of spaced connector support pins protruding from the chamber walls and for reception in corresponding sockets in a power supply pack of a complementary profile to the separation chamber.

Conveniently, the power pack and separation chamber share a common cover plate, for example carried by the power pack, which may be totally enclosed or even sealed for security and safety.

A plurality of separation wells may be embodied in a given separation chamber enclosure housing or body.

Test chamber sub-division or gel casting plates may be located in grooves in the internal surface of the chamber walls.

Ports may be incorporated for the re-circulation of running medium.

There now follows a description of some particular embodiments of the invention, by way of example only, with reference to the accompanying diagrammatic and schematic drawings, in which:

Figure 1 shows an integrated electrophoresis unit;

Figure 2 shows a longitudinal side elevation of the unit of Figure 1;

Figure 3 shows an end elevation of the unit of Figures 1 and 2;

Figure 4 shows an opposite end elevation to that of Figure 3;

Figures 5A and 5B show the provision of removable gel casting plates in the unit of Figures 1 through 4; and

Figure 6 shows the unit of Figures 1 through 5, split into two principal elements.

Referring to the drawings, a portable, self-contained, low voltage, electrophoresis unit 10 comprises a separation chamber 11 and a battery pack 12, intercoupled electro-mechanically by pairs of spaced (snugly) interfitting connector sockets 15, 16 and complementary pins 17, 18.

A common cover plate or lid 22 integrated with the battery chamber 11 overlies the separation chamber 12, which is otherwise configured as a shallow rectangular tray, partitioned by removable internal sub-divider plates 33, 34, 36 described later.

The secure male-female interfit of the spaced pin and socket interconnection 15, 16, 17, 18 along with the common lid 22 form a mechanically braced conjoined assembly 10, which can be picked up as a whole by grasping either the battery compartment 11 or separation chamber 12.

The readily effected joining and separation of the units 11 and 12 by a linear relative sliding action and its reversal are depicted by double-headed arrow 27.

The battery pack 11 houses a pair of discrete battery compartments 19, 21, with battery slider mounting trays 23, 25 respectively with in-built battery terminal connectors, for individual proprietary dry cell batteries (not shown).

The sockets 15, 16 represent terminals of opposite (ie positive and negative) polarity and are electrically connected by internal wiring to the battery compartments 19, 21.

For ease of reference and to avoid mis-connection, the terminals may be colour-coded (say with the convention red for positive, black for negative).

The disposition (eg spacing relative to the lid 22) and configuration of connectors 15, 16, 17, 18 may also be such as to allow only the correct relative orientation and polarity interconnection of the units 11 and 12.

The pins 17, 18 are in turn connected to internal electrode wires 28, 29 respectively, extending longitudinally between opposed pairs of mounting bosses 31, 32, integrally moulded with the side walls 13, 14 of the separation chamber 12.

As is more readily appreciated from Figures 3 and 5, the electrode wires 28, 29 run close to the side walls 13, 14 of the separation chamber 12, in compartments 37, 39, which are temporarily (sub-) divided off from the main chamber 41 by removable partition walls, or so-called gel casting plates 33, 34.

The gel casting plates 33, 34 are located in opposed pairs of grooves 44, 45 in the separation chamber end walls 47, 48.

An additional slotted, or multiple toothed gel casting plate or comb 36 alongside one of the plates 33 forms wells in the gel for sample loading.

The comb 36 is of T-shaped profile in plan, with relatively short side limbs which located in shallower slots 49 in the end walls 47, 48.

In use a substrate gel (not shown), is introduced into the separation chamber 41, with the gel casting plates 33, 34 serving as 'casting gates', and comb 36 in place.

The gel is allowed to set and the plates 33, 34 and 36 then removed, leaving a 'cast' substrate - on to which can be introduced test samples and marker dye.

An electrical voltage applied across the electrodes 28, 29 to allow the electrophoresis effect - which can be monitored by exposure to ultraviolet (UV) inspection light. To facilitate this, some of the chamber 12 walls are desirably translucent, even transparent.

The entire assembly may be fabricated from thick-walled acrylic plastics material.

For electrical efficiency, ie low resistance losses and attendant heating, gold-plated connectors and platinum electrode wires may be used.

Principal feature of the invention are:

- Operability at relatively low voltages - that is a few volts - for example 18 volts, conveniently generated by combining two proprietary 9 volt dry cells - compared with some 100 volts employed conventionally, and which must be generated from a mains supply.

- Portability - in part a consequence of the ability to run from low voltage batteries. This allows in-field testing, not feasible with conventional high voltage mains units.

- Integrated construction, enabling a compact unit, which promotes portability.

- Flexibility - with a readily split and conjoined two component design, with interconnectors combining mechanical coupling and support with electrical feed - allowing the power pack to be changed with ease, by a simple push-fit action.

- Safety - by the low voltage operation, reduces experimental hazards and is particularly advantageous for educational use, with younger and inexperienced students.

Components list:

Figures 1 through 6

10	electrophoresis unit
11	(battery) power supply
12	separation chamber
13	side wall: chamber 12
14	side wall: chamber 12
15	socket connector +/-ve polarity
16	socket connector +/-ve polarity
17	pin connector
18	pin connector
19	battery compartment
20	
21	battery compartment
22	cover plate/lid
23	l.h. battery slide
24	
25	r.h. battery slide
26	
27	arrow: separation-battery separation-union
28	electrode wire
29	electrode wire
30	
31	mounting boss
32	mounting boss
33	gel casting plate
34	gel casting plate
35	
36	comb
37	(sub-)compartment
38	
39	(sub-)compartment
40	
41	(main) compartment
42	
43	
44	mounting grooves: plate 33
45	mounting grooves: plate 34
46	
47	end wall: chamber 12
48	end wall: chamber
49	mounting slot: comb 36
50	

Claims

1.

A portable, self-contained, electrophoresis unit 10 comprising
a separation chamber (12)
a battery pack (11)
complementary interfitting electromechanical connectors (15, 16, 17, 18)
on the separation chamber and battery pack,
for effecting mechanical support and electrical connection therebetween.

2.

An electrophoresis unit, as claimed in Claim 1, operable at relatively low voltages - specifically with an operating voltage of at or under some 50 volts DC.

3.

An electrophoresis unit, as claimed in Claim 2, employing an operating voltage of some 18 volts, for example generated from two 9 volt batteries wired in series.

4.

An electrophoresis unit as claimed in any preceding claim, with plug-and-socket connectors as an interference or spring-loaded push fit into one another, to facilitate interconnection and separation.

5.

An electrophoresis unit, substantially as hereinbefore described, with reference to, and as shown in, the accompanying drawings.

6.

An electrophoretic separation method or process, including the step of applying a low voltage - that is for example of 50 volts or less - to a sample under test, and allowing the resulting electric field to promote the migration of molecules in a matrix medium.

7.

A low voltage electrophoretic separation method or process, as claimed in Claim 6, using the apparatus as claimed in any of Claims 1 through 5.

8.

An electrophoretic separation method, substantially as hereinbefore described, with reference to, and as shown in, the accompanying drawings.

The Patent Office

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Application No: GB 9512880.7
Claims searched: 1-5 and 7.

Examiner: David Mobbs
Date of search: 2 July 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G1N NBLE.

Int Cl (Ed.6): BO1D 57/02; G01N 27/447, 27/453.

Other: ONLINE: CLAIMS, INSPEC, JAPIO WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2,276,008 A	(UNIVERSITY OF READING) - note particularly page 5 lines 7-11.	1-4, 7.
Y	GB 1,515,390	(THE BLACK AND DECKER MANUFACTURING COMPANY)	1-4, 7.
Y	US 5,209,831	(MACCONNELL)	1-4, 7.
Y	US 5,106,477	(GENELEX CORPORATION)	1-4, 7.
Y	US 4,608,146	(BIO-RAD LABORATORIES)	1-4, 7.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.